Europäisches Patentamt
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(19) (11) Publication number: 0 326 318 A2

EUROPEAN PATENT APPLICATION

(12)

(21) Application number: 89300631.2

(51) Int. Cl.[4]: H 05 H 1/34

(22) Date of filing: 24.01.89

(30) Priority: 25.01.88 NO 880288

(43) Date of publication of application: 02.08.89 Bulletin 89/31

(84) Designated Contracting States: AT BE CH DE ES FR GB GR IT LI LU NL SE

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(54) Plasma torch.

(57) A plasma torch intended to be submerged in a bath of molten metal, such as a steel melt. The torch comprises an outer electrode (1) made from a non-consumable material and an inner electrode (1a). The outer electrode (1) is a copper pipe having internal channels for a cooling medium, and having a layer of refractory material (7) on the outside. The layer of refractory material has a thickness between 1 and 5mm and is made from Al_2O_3 or from ZrO_2 stabilised with 5-25% by weight of MgO and/or Y_2O_3, or from oxides of other rare earth elements.

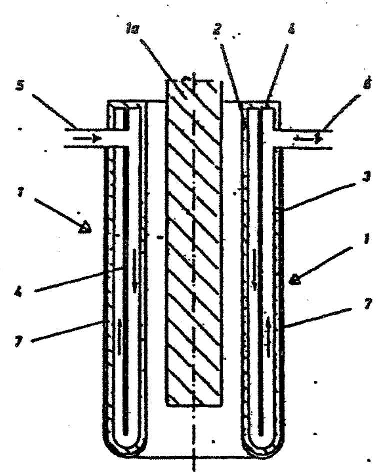

Fig. 1

Bundesdruckerei Berlin

Description

PLASMA TORCH

The present invention relates to a plasma torch for generating a high temperature plasma by means of an electric arc between a ring-shaped outer electrode and an inner electrode arranged coaxially in the outer electrode. More specifically the present invention relates to a plasma torch of this kind which is intended to be submerged in molten metal such as a bath of molten steel.

Plasma torches which are intended to be submerged in molten metal in which the electrodes are made from a consumable matelal such as for example graphite are known. These torches, however, have a number of drawbacks and disadvantages. Graphite electrodes quite frequently break, resulting in disruption of the heating of the metal melt. Also, graphite electrodes cannot be used with metal melts in which graphite dissolves, such as steel melts, melts of ferromaganese, etc. Furthermore, the plasma torch has to be equipped with means for feeding of the graphite electrodes as these are consumed; this makes the design of the plasma torch complex. Finally the consumption of the graphite electrode is the main factor which leads to high operating costs for this kind of plasma torch.

It is an object of the present invention to provide a plasma torch for heating a molten metal bath by submerging the torch in the bath, where at least the outer electrode is made from a non-consumable material.

According to the present invention, a plasma torch is characterised in that the outer electrode is non-consumable and comprises a copper pipe having an internal channel for a cooling medium, and having a layer of refractory material at least on its outside.

According to a preferred embodiment, the layer of refractory material consists of Al_2O_3 or ZrO_2 stabilised with 5-25%, preferably 20% MgO and/or Y_2O_2, or of oxides of other rare earth elements. The layer of refractory material may have a thickness of 1-5mm, preferably 2-4mm and is preferably applied by flame- or plasma spraying.

The inner electrode may consist of a cooled or non-cooled copper pipe or may be of a consumable material, such as graphite. The current supply to the electrodes is preferably arranged in such a way that the arc will rotate about the tip of the outer electrode.

An alternative embodiment of the present invention includes a pipe made from a ceramic material such as aluminium oxide, on the outside and at a distance from the outer ring-shaped electrode. The pipe is open at its lower end, whereby molten metal can flow into the annulus between the outer electrode and the ceramic pipe.

An oil or molten metal having a low melting temperature, may be used as the cooling medium for cooling the outer electrode.

The plasma torch according to the present invention can further be equipped with means which makes it possible to supply alloying additions to the metal melts through the annulus between the inner and the outer electrode.

The thermal insulating layer of refractory material on the outside of the outer electrode has a number of functions. Firstly, the copper pipe is protected against thermal and chemical stress when the torch is submerged in the molten bath. The lifetime of the outer electrode can thereby be substantially increased. Secondly the layer on the outer electrode acts as a thermal barrier between the molten metal and the copper pipe, whereby heat which is removed from the melt by the internal cooling of the copper pipe is substantially reduced. Thus, the thermal efficiency of the torch is increased. In the case of the plasma torch with an outer electrode comprising a cooled copper pipe without an outer layer, the heat loss from the metal bath through the copper pipe and through the cooling medium would be substantial and would reduce the thermal efficiency of the plasma torch.

In operation a gas is preferably supplied to the annulus between the outer and the inner electrodes and the electric arc is struck between the electrode tips. The inside of the outer electrode and the inner electrode may be cooled by the gas which is supplied to the annulus and it would therefore not normally be necessary to have a layer of refractory material on these parts.

By arranging a ceramic tube on the outside of, and at a distance from, the outer ring-shaped electrode, increased protection of the plasma torch may be obtained. When a plasma torch equipped with such a ceramic tube is submerged into a metal bath, molten metal will flow into the annulus between the outer electrode and the ceramic tube. The molten metal in this annulus will be more or less at rest and will tend to protect the outer electrode.

The invention may be carried into practice in various ways and two embodiments will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a vertical section through a plasma torch according to the present invention, and

Figure 2 is a similar view showing a second embodiment in which the outer electrode is surrounded by a ceramic tube.

The plasma torch shown in Figure 1 comprises an outer electrode 1 and an inner electrode 1a. The outer electrode 1 consists of a ring-shaped copper pipe having an inner wall 2 and an outer wall 3. The copper pipe is equipped with an internal wall 4 which extends downwards from the top of the pipe and stops above the bottom of the copper pipe. The copper pipe is further equipped with an inlet opening 5 and an outlet opening 6 for a liquid cooling medium.

The copper pipe has on its outer wall 3 a layer 7 of refractory material. The layer of refractory material preferably has a thickness of 1-5mm and is made from Al_2O_3 or from ZrO_2 stabilised with 5-25% MgO and/or Y_2O_3 and is made by flame- or plasma

spraying. On the lower end of the copper pipe there are preferably inserts made from Wolfram (tungsten), graphite or some other high-temperature resistant material having a low electrical resistivity. Due to the electric arc produced, the inserts on the lower end of the copper pipe will be worn and will have to be replaced from time to time.

The plasma torch has a conventional means for the supply of electric current to the torch (not shown) and is equipped with means for the supply of a gas, such as for example, argon to the annulus between the inner and the outer electrodes.

Figure 2 shows a second embodiment of a plasma torch according to the present invention. In this case, the plasma torch is similar to the embodiment of Figure 1 except hat it is equipped with a ceramic tube 8 located around and spaced from the outer ring-shaped electrode. The tube 8 is open at its lower end and is fixed to the outside of the outer electrode. The length of the ceramic tube 8 is such that the tube extends upwards to a level which is at least above the top of the metal bath when the plasma torch is submerged in the bath.

When the plasma torch is submerged in a metal bath, molten metal will fill the annulus between the outer electrode 1 and the ceramic tube 8. As long as the torch is submerged, the metal in the annulus between the outer electrode 1 and the ceramic tube will more or less be at rest. This part of the molten metal will thus protect the outside of the outer electrode against continuous flow of holt molten metal near the outside of the outer electrode. The heat stress on the layer of refractory material and on the copper pipe will thereby be reduced and the life-time of the plasma torch will be increased.

Claims

1. A plasma torch for generating a high -temperature plasma by means of an electric arc struck between an outer ring-shaped electrode (1) and an inner electrode (1a) coxially located within the outer electrode (1), characterised in that the outer electrode (1) is non-consumable and comprises a copper pipe having internal channel for a cooling medium, and having a layer (7) of refractory material at least on its outside.

2. A plasma torch as claimed in Claim 1 characterised in that the layer (7) of refractory material has a thickness between 1 and 5mm, preferably between 2 and 4mm.

3. A plasma torch as claimed in Claim 1 or Claim 2 characterised in that the layer of refractory material consists of ZrO_2 stabilised with 5-25% preferably 20% MgO and/or Y_2O_3, or of oxides of other rare earth elements.

4. A plasma torch as claimed in any preceding claim characterised in that the refractory layer (7) is applied by flame- or plasma spraying.

5. A plasma torch as claimed in Claim 1 or Claim 2 characterised in that the refractory layer (7) consists of Al_2O_3 which has been applied by flame- or plasma spraying.

6. A plasma torch as claimed in any preceding claim, characterised by a sleeve or tube (8) made from a ceramic material arranged outside and spaced from the outer electrode (1).

7. A plasma torch as claimed in Claim 5, characterised in that the ceramic tube (8) is made from aluminium oxide.

8. A plasma torch as claimed in any preceding claim characterised in that the inner electrode (1a) is made from graphite or from copper having internal channels for the circulation of a cooling medium.

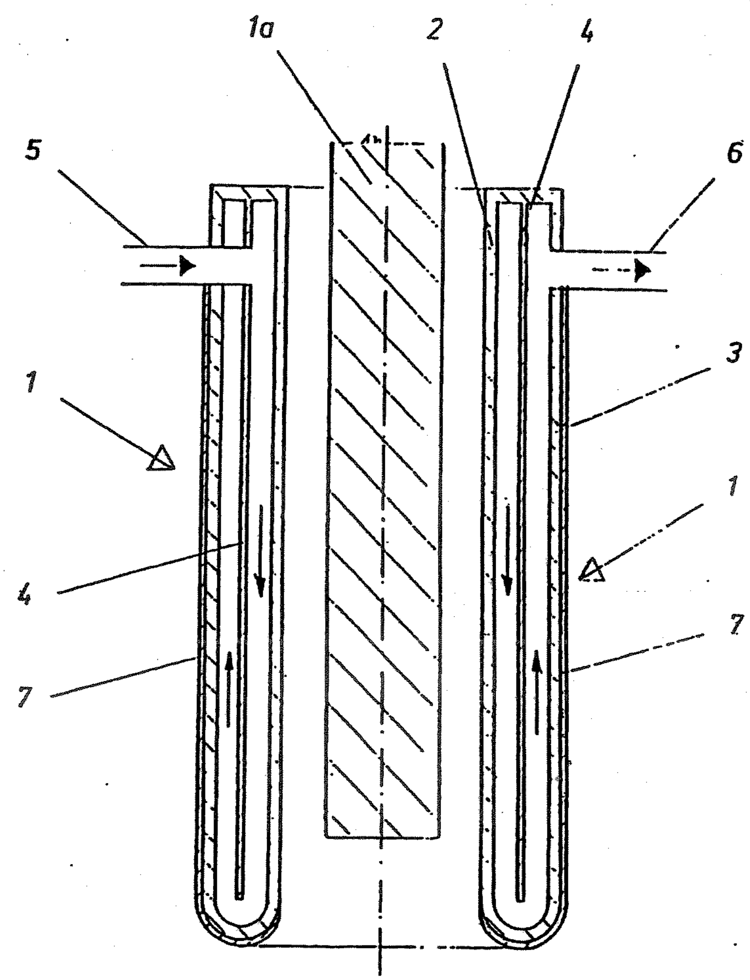

Fig. 1